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AFOSR Young Investigators Program: Understanding Intense Laser Interactions with Solid Density Plasma

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Final Report

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Thomas, Alexander GR

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14. ABSTRACT

We have performed time resolved measurements of the interaction of an ultrafast laser with thin solid density foil using wakefield accelerated electrons. Recent progress in laser wakefield acceleration has led to the emergence of a new generation of electron and X-ray sources that may have enormous benefits for ultrafast science. These novel sources promise to become indispensable tools for the investigation of structural dynamics on the femtosecond time scale, with spatial resolution on the atomic scale. We have demonstrated for the first time the use of laser-wakefield-accelerated electron bunches for time-resolved electron diffraction measurements of the structural dynamics of single-crystal silicon nano-membranes pumped by an ultrafast laser pulse. In our proof-of-concept study, we resolve the silicon lattice dynamics on a picosecond time scale by deflecting the momentum-time correlated electrons in the diffraction peaks with a static magnetic field to obtain the time-dependent diffraction efficiency. Further improvements may lead to femtosecond temporal resolution, with negligible pump-probe jitter being possible with future laser-wakefield-accelerator ultrafast-electron-diffraction schemes. Z.-H. He, et al. A. G. R. Thomas & J. Faure, Capturing Structural

15. SUBJECT TERMS

Laser plasma interactions, solid density plasma, time resolved pump-probe measurements, electron diffraction

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Contract/Grant #: FA9550-12-1-0310
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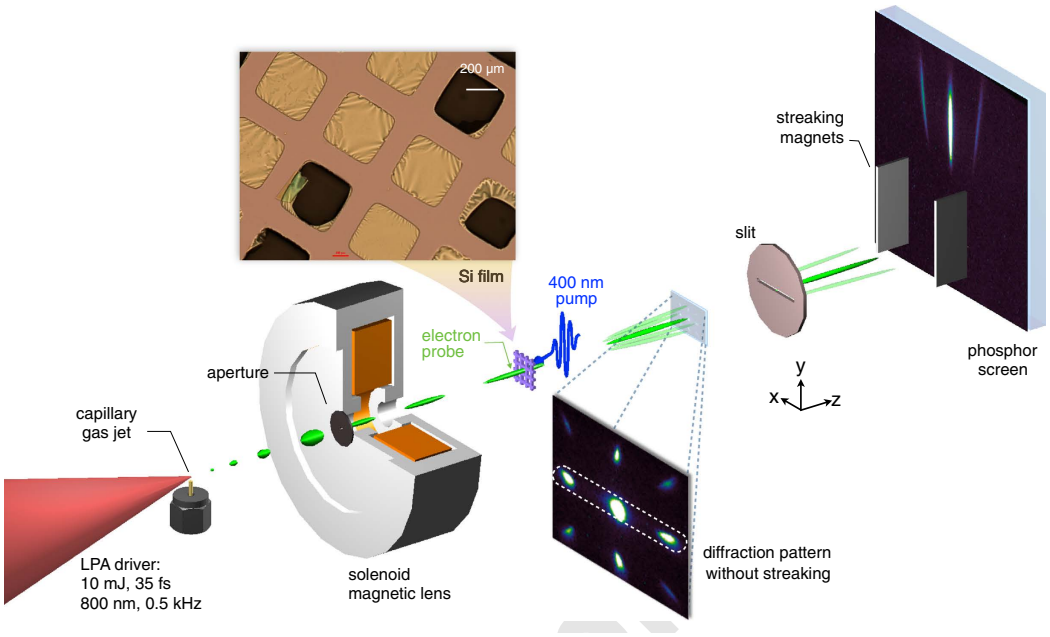

Annual accomplishments (200 words max): .

We have performed time resolved measurements of the interaction of an ultrafast laser with thin solid density foil using wakefield accelerated electrons. Recent progress in laser wakefield acceleration has led to the emergence of a new generation of electron and X-ray sources that may have enormous benefits for ultrafast science. These novel sources promise to become indispensable tools for the investigation of structural dynamics on the femtosecond time scale, with spatial resolution on the atomic scale. We have demonstrated for the first time the use of laser-wakefield-accelerated electron bunches for time-resolved electron diffraction measurements of the structural dynamics of single-crystal silicon nano-membranes pumped by an ultrafast laser pulse. In our proof-of-concept study, we resolve the

silicon lattice dynamics on a picosecond time scale by deflecting the momentum-time correlated electrons in the diffraction peaks with a static magnetic field to obtain the time-dependent diffraction efficiency. Further improvements may lead to femtosecond temporal resolution, with negligible pump-probe jitter being possible with future laser-wakefield-accelerator ultrafast-electron-diffraction schemes. [2]

Archival publications (published) during reporting period:

1) C. Zulick, A. Raymond, A. McKelvey, V. Chvykov, A. Maksimchuk, A. G. R. Thomas, L. Willingale, V. Yanovsky, and K. Krushelnick, Target surface area effects on hot electron dynamics from high intensity laser-plasma interactions, New J Phys. 18, 063020 (2016).

2) Z.-H. He, B. Beaurepaire, J. A. Nees, G. Gallé, S. A. Scott, J. R. Sánchez Pérez, M. G. Lagally, K. Krushelnick, A. G. R. Thomas & J. Faure, Capturing Structural Dynamics in Crystalline Silicon Using Chirped Electrons from a Laser Wakefield Accelerator Scientific Reports (Accepted 2016).

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Change in AFOSR program manager, if any:

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Include any new discoveries, inventions, or patent disclosures during this reporting period (if none, report none): None

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Principal Investigator Name

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Alexander Thomas

Program Officer

The AFOSR Program Officer currently assigned to the award

Jason Marshall

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Reporting Period End Date

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Abstract

We have performed time resolved measurements of the interaction of an ultrafast laser with thin solid density foil using wakefield accelerated electrons. Recent progress in laser wakefield acceleration has led to the emergence of a new generation of electron and X-ray sources that may have enormous benefits for ultrafast science. These novel sources promise to become indispensable tools for the investigation of structural dynamics on the femtosecond time scale, with spatial resolution on the atomic scale. We have demonstrated for the first time the use of laser-wakefield-accelerated electron bunches for time-resolved electron diffraction measurements of the structural dynamics of single-crystal silicon nano-membranes pumped by an ultrafast laser pulse. In our proof-of-concept study, we resolve the silicon lattice dynamics on a picosecond time scale by deflecting the momentum-time correlated electrons in the diffraction peaks with a static magnetic field to obtain the time-dependent diffraction efficiency. Further improvements may lead to femtosecond temporal resolution, with negligible pump-probe jitter being possible with future laser-wakefield-accelerator ultrafast-electron-diffraction schemes.

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1) C. Zulick, A. Raymond, A. McKelvey, V. Chvykov, A. Maksimchuk, A. G. R. Thomas, L. Willingale, V. Yanovsky, and K. Krushelnick, Target surface area effects on hot electron dynamics from high intensity laser-plasma interactions, New J Phys. 18, 063020 (2016).
2) Z.-H. He, B. Beaurepaire, J. A. Nees, G. Gallé, S. A. Scott, J. R. Sánchez Pérez, M. G. Lagally, K. Krushelnick, A. G. R. Thomas & J. Faure, Capturing Structural Dynamics in Crystalline Silicon Using Chirped Electrons from a Laser Wakefield Accelerator Scientific Reports (Accepted 2016).

New discoveries, inventions, or patent disclosures:
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Changes in research objectives (if any):

N/A

Change in AFOSR Program Officer, if any:

N/A

Extensions granted or milestones slipped, if any:

This years funding was an extension on the project from last year. It enabled us to carry out the work on probe-probe electron diffraction measurements of ultrafast laser-solid target interactions that has been accepted for publication.

AFOSR LRIR Number

LRIR Title

Reporting Period

Laboratory Task Manager

Program Officer

Research Objectives

Technical Summary

Funding Summary by Cost Category (by FY, $K)

	Starting FY	FY+1	FY+2
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